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# Investigation of the Relation between Information Process Capacity and Workload in Diagnosis Tasks

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## 1. Introduction

In this paper, a measurement method of the information process capacity of human was investigated when an operator in a main control room (MCR) of a nuclear power plant (NPP) is conducting diagnosis tasks. According to operators' expertise, their information process capacities are changed. To measure this capacity quantitatively, the information flow that can quantify the complexity of diagnosis tasks in bits was used [1]. As the information flow rate is increased, the operator's mental workload is also increased [2]. Through the experiment, the relation between the information process capacity and the operator's workload was investigated. Therefore the operator's information process capacity could be found.

## 2. Information Process Capacity

The information process capacity is the amount of the information in bit that an operator can manage per one second. To measure this information process capacity quantitatively, the information flow is used. If the information flow (bit) is divided by the given time (sec), the information flow rate (bit/sec) is obtained.

The workload is related to human's performance. That is, high workload makes human's bad performance and low workload makes good performance.

In this paper, compared to subject's mental workload for each information flow rate, if the workload is increased rapidly at some information flow rate then that information flow rate is the information process capacity. Because rapid workload increase means subject's bad performance, and moreover that means overflow of his/her own information process capacity.

## 3. Experiment

The experiments were conducted to investigate the relationship between the operator's mental workload and the information flow rate of eight accident diagnosis tasks. To measure each subject' workload, NASA-TLX was used [3]. Through the experiments, the relationship between the information flow rate and the subjects' mental workload was analyzed. In the relation we could find the subjects' information process capacity.

### *3.1 Experiment Set up*

The subjects were asked to diagnose eight accident cases within a constrained time limit from the interface of a Nuclear Steam Supply System (NSSS) overview (Figure 1). The FISA-2/WS used in the experiments is a real-time micro-simulator and was developed at KAIST [4].

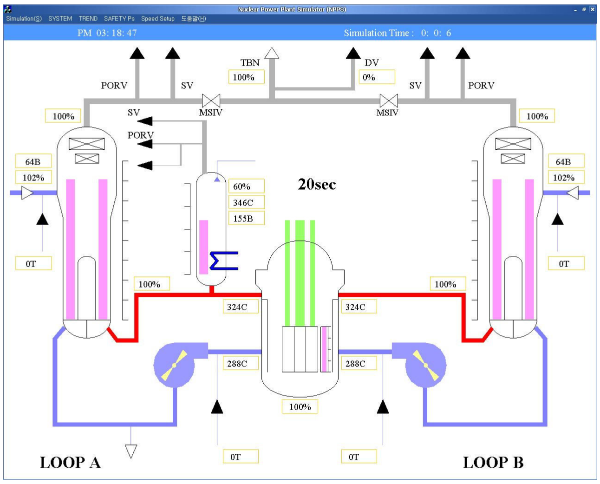


Figure 1. Interface of a Nuclear Supply System overview (FISA-2/WS)

The information flows of eight accident diagnosis tasks are modeled and quantified using Conant's model [5]. The eight accident cases are: Reactor Coolant Pump trip (RCP), PZR spray failure, Main Steam Isolation Valve (MSIV) failure, PZR heater failure and spray failure, Feedwater Line Break (FLB), Loss Of Coolant Accident (LOCA), Steam Generator Tube Rupture (SGTR), and Steam Line Break (SLB). Table 1 shows the information flow rate using the information flow and time limit of the eight accident diagnosis tasks.

| | RCP trip | PZR spray fail | MSIV fail | PZR fail & Spray fail | FLB | LOCA | SGTR | SLB |
|---|---|---|---|---|---|---|---|---|
| Information Flow (bit) | 8.81 | 11.54 | 11.54 | 12.62 | 13.16 | 18.34 | 30.69 | 39.09 |
| Time Limit (sec) | 25 | 25 | 22 | 21 | 20 | 22 | 30 | 31 |
| Information Flow rate (bit/sec) | 0.3524 | 0.4616 | 0.5245 | 0.6010 | 0.6580 | 0.8336 | 1.023 | 1.1845 |

Table 1. Information flow rate using information flow and time limit of eight accident diagnosis tasks

### *3.2 Experiment Procedure*

All subjects were trained to diagnose eight accident cases: to perceive the signs, identify the symptoms, and diagnose the cause of the accident for each task. The subjects were required to diagnose the accident within a restricted time limit. After each diagnosis task was completed, the subjects were immediately asked to subjectively rate their experience using a software-version of NASA-TLX that could measure the subjects' mental workload.

### *3.3 Result*

Figure 2 shows graphs between the information flow rate and the workload of subjects, respectively. There were four subjects who were majoring in nuclear engineering.

In subject A, the workload from the information flow rate 0.3524 to 1.1845 (bit/sec) was increased slightly. In case B, the workload from the information flow rate 0.3524 to 0.658 (bit/sec) varied gradually, but the workload from the information flow rate 0.658 to 0.8336 (bit/sec) was increased rapidly. In subject C and D, workload from the information flow rate 0.3524 to 0.601 (bit/sec) varies gradually, but workload from the information flow rate 0.601 to 0.658 (bit/sec) was increased rapidly.

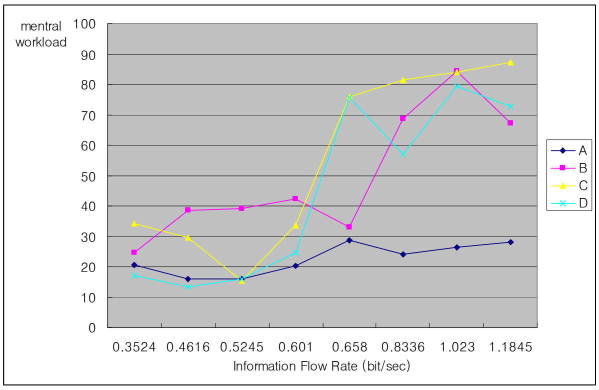


Figure 2. Information flow rate versus workload

## 4. Discussion

From the experiment, the subjects' information process capacity (bit/sec) was observed. The information process capacity is the point at which the information flow rate is increased rapidly. The subject B has the information process capacity from 0.658 to 0.8336 (bit/sec). The subject C and D have the information process capacity from 0.601 to 0.658 (bit/sec). However the information process capacity of the subject A is unclear, because the subject A has understood this interface and diagnosis tasks very well. Hence the workload differences in subject A are comparatively small.

Using this operator's information process capacity, we can apply this capacity to diagnose task design and predict an operator's performance when the operator is conducting some diagnosis tasks in a NPP. Also, after the information process capacity when operator can manage some tasks (bit/sec) is clearly investigated, it can be applied to the interface design.

Further work, we'll focus on investigating the information process capacity levels as operator's expertise (e.g. experience, and novice). More experiments would be executed for theory testing.

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